

# Seismicity and Focal Mechanism of Earthquakes of HinduKush Region

by

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## Location and Tectonics of HinduKush

- Hindukush is located in the north of Himalayas.
- Himalayas is a mountain system in the Southern Asia.
- It is highest in the world 1500 miles long and 150 miles wide.
- The continent-continent collision between Indian and Eurasian plates during the past 40 million years produced Himalayas.

## Location and Tectonics of HinduKush

- Indian plate is moving towards northward relative to Eurasian plate at a rate of 5cm/year, making Indian-Eurasian collision zone one of the most seismically active region in the world.
- It contributes 15% of yearly global seismic energy release.
- Pakistan is located ( $23.34^{\circ}$  to  $37.06^{\circ}$ N and  $60.87^{\circ}$  to  $79.56^{\circ}$ E) along the western boundary between the Eurasian and Indian plates.

## Location and Tectonics of HinduKush

- Because of its proximity to the Eurasian-Indian plate boundary the HinduKush seismic zone is believed to be grossly related to the convergence of Indian and Eurasian subcontinents.
- **PREVIOUS WORK**  
Chatelian et al. (1980) studied this region and found very little seismic activity in the crust from 0-70 km .

## Previous work

- According to them, the seismic activity is broader between depths of 70-160km and their fault plane solutions do not show a consistent pattern.
- The events greater than 160km depth show a consistent pattern.
- This study is an attempt to know seismicity and its relationship to the seismotectonics in the HinduKush region.
- Data
- IRIS-International Research Institute of Seismology.

## Data

- MSSP-Micro Seismic Studies Program, Operating 30 short Period stations few of them are in the vicinity of Hindukush.
- Five Years seismicity with events having Magnitude  $\geq 5$  is considered.
- Region-  $34^{\circ}$  to  $38^{\circ}$ N and  $67^{\circ}$  to  $73^{\circ}$ E
- Total events in this region = 51
- Analyzed P-wave on vertical component for short period SP as well as BHZ.
- First study which used the data of MSSP to know seismicity of Hindukush region. So this feature is the uniqueness of this study.

## THEORY and METHODOLOGY

- Seisan version 7.1 was used to analyze the seismograms.
- Merged the MSSP & IRIS data together to get best locations.
- The first P-wave arrivals were picked along with polarities.
- The Hypocentres were determined by using HYPOCENTRE.
- Calculated body wave magnitude for all events. The epicentres and depth profiles were plotted by EPIMAP.

## THEORY and METHODOLOGY

- Fault plane solution determined by using FOCMEC. A program which makes a grid search to determine the solutions that minimize the misfit.

## ➤ RESULTS

- Seismicity is scattered but low for the shallow 0-100km deep earthquakes and it is lying between  $34^{\circ}$  to  $38^{\circ}$ N and  $67^{\circ}$  to  $73^{\circ}$ E.<sup>22</sup>



## Results continued

- For the events 100 to 170km deep it becomes confined and low. <sup>23</sup>
- For the intermediate depth earthquakes, 170 to 250km deep, seismicity is more active and even narrower than in the shallower region and lies within  $36.2^{\circ}$  to  $36.7^{\circ}$  N and  $69.8^{\circ}$  to  $71.6^{\circ}$  E. <sup>24</sup>

## Results continued

- There is an aseismic region from  $35^{\circ}$  to  $36^{\circ}$ N and a 30km aseismic gap from 150 to 180km depth.<sup>20</sup>
- Fault Plane Solutions at depths of 0-100km
- Southern region of studied area has three reverse fault events. Fault plane solutions of northern events do not have consistent pattern.<sup>22</sup>
- Fault Plane Solutions at depths of 100-170km
- This zone seems mixture of all types i.e. strike-slip, reverse and normal.<sup>23</sup>

## Results continued

### Fault Plane Solutions at depths of 170-250km

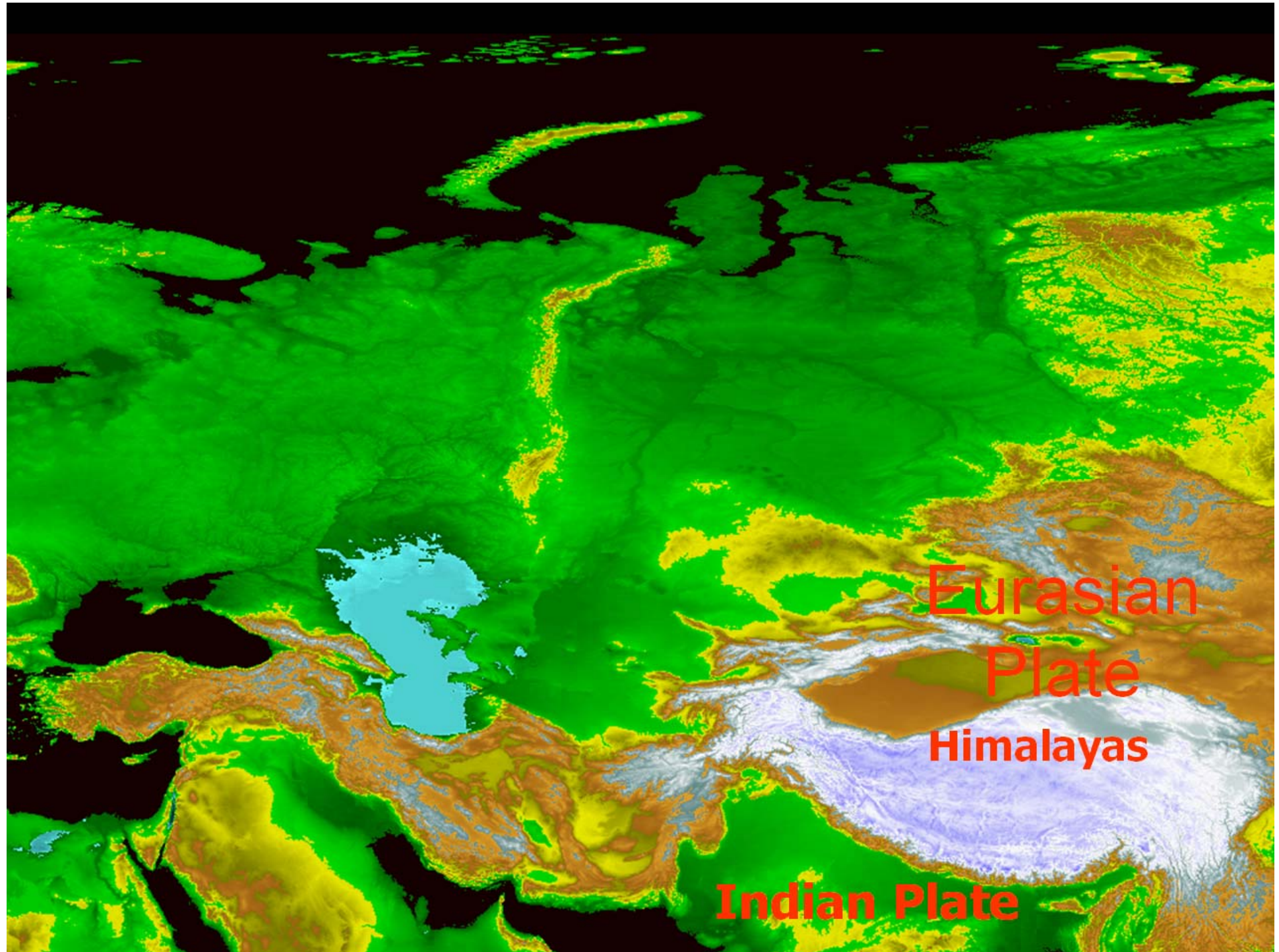
- Most of the earthquakes highlight either reverse-type faulting or reverse faulting with a small component of strike slip.<sup>24</sup>

## Discussions and conclusions

- The intermediate depth seismicity of the Hindukush is confined to small isolated area, roughly 100km in extent from 70° to 71°E. There is a little but scattered seismicity for shallower earthquakes, It is almost upto 500km in extent.

## Discussions continued

- No earthquake was observed deeper than 250km for the entire zone.<sup>19</sup>
- The seismic zone of Hindukush is highly twisted and consists of several zones separated by gaps of aseismicity. Two of the most prominent gaps: one from 35° to 36°N and another that separates events deeper than 170km.
- There is no proper uniformity among the fault plane solutions but the general trend of the deeper earthquakes reveals that reverse faulting is dominant.



**Eurasian  
Plate  
Himalayas**

**Indian Plate**

# Plate Boundaries in Pakistan

China

Eurasian Plate

CHITRAL

ISLAMABAD

MIANWALI

LAHORE

QUETTA

CKHAN

BAHAWALPUR

India

Indian Plate

Eurasian Plate

Afghanistan

Iran

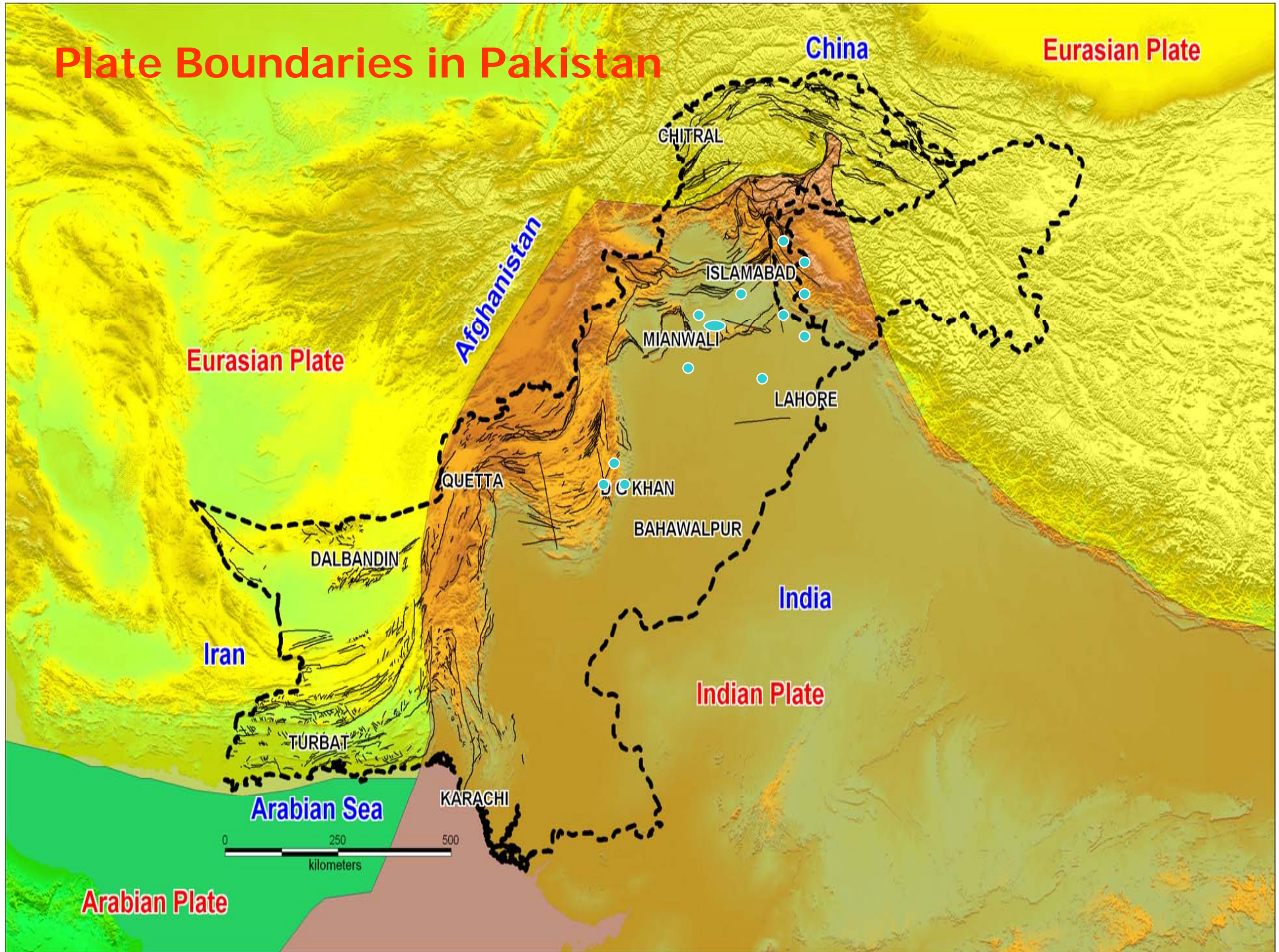
DALBANDIN

TURBAT

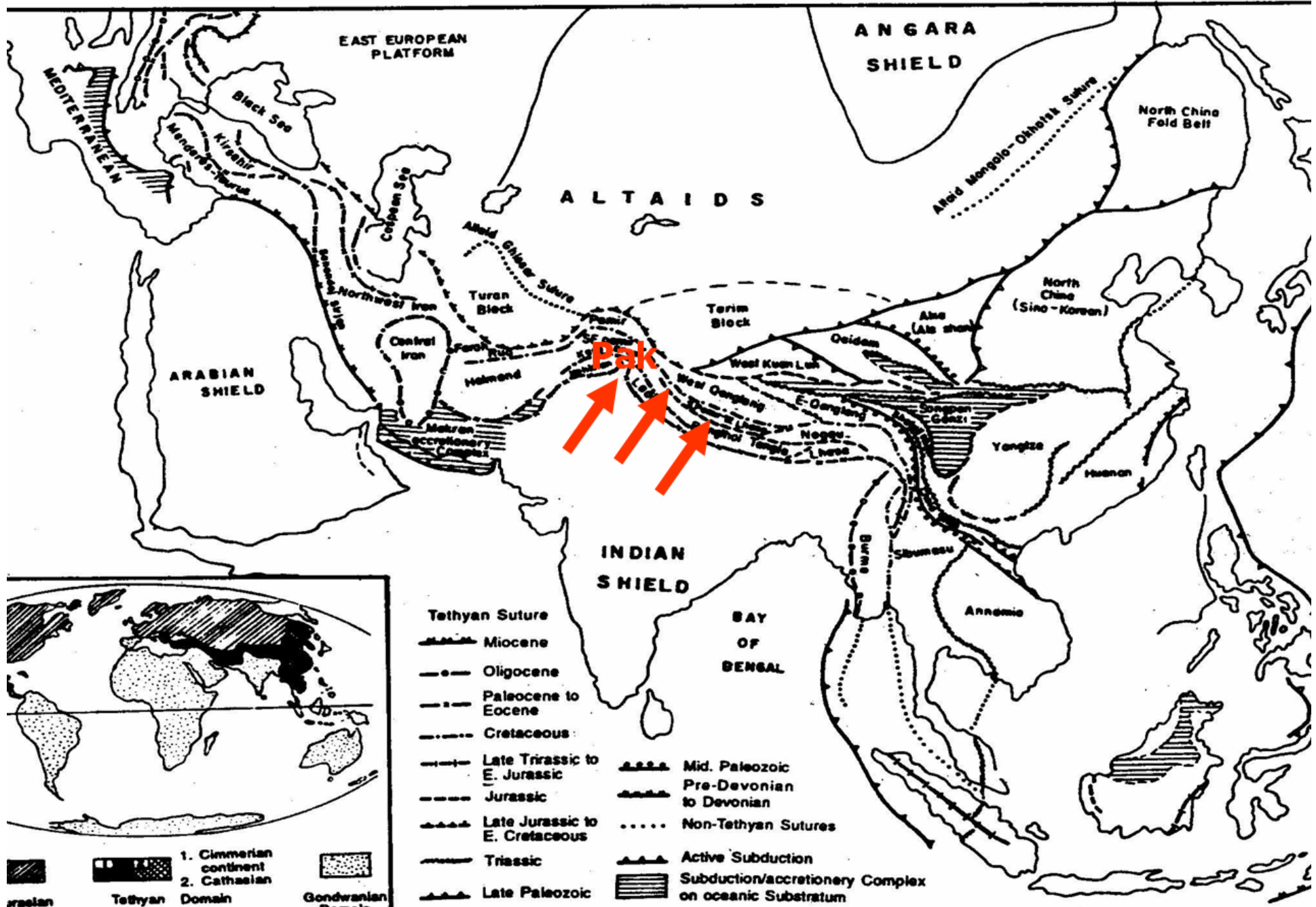
Arabic Sea

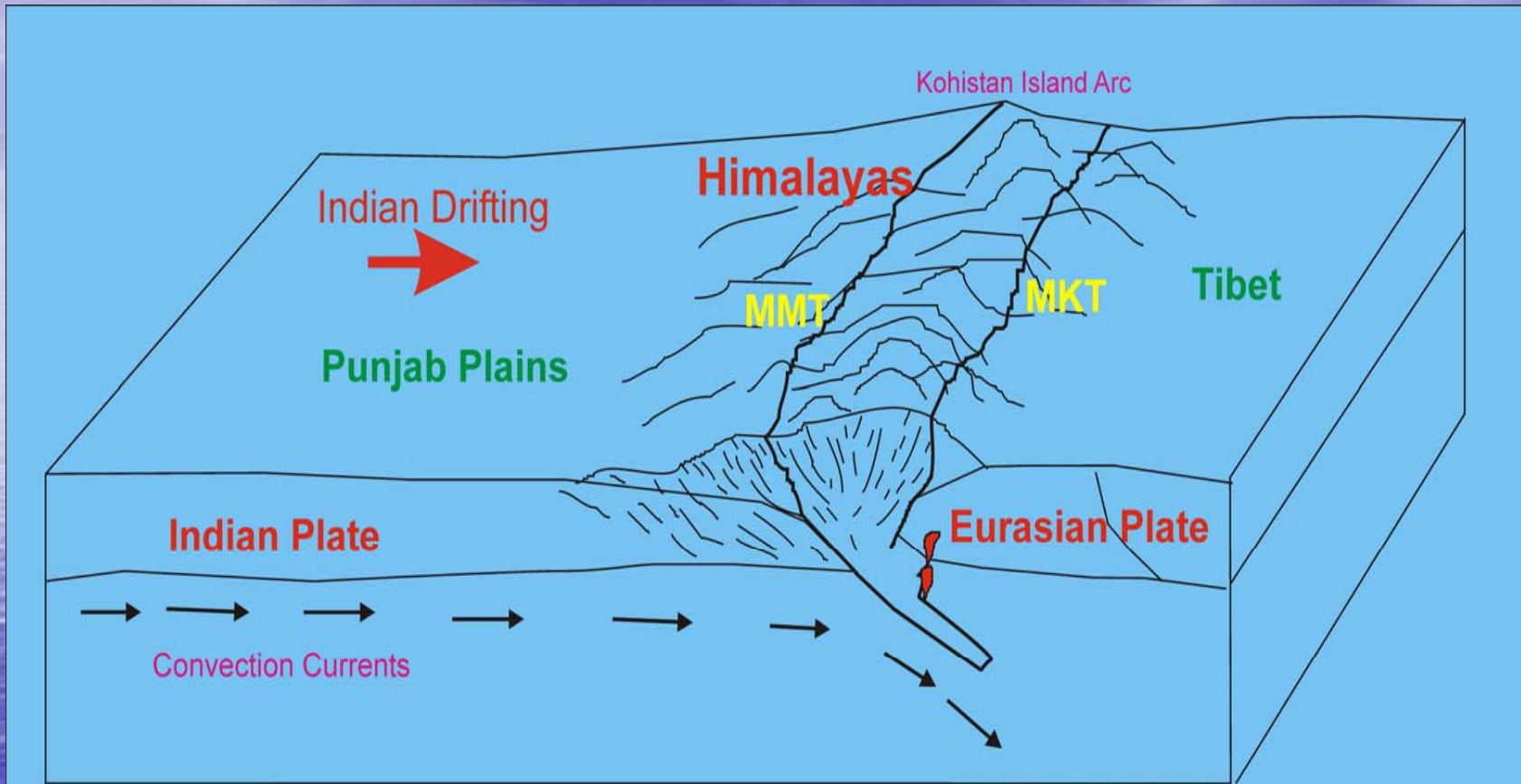
KARACHI

Arabic Plate

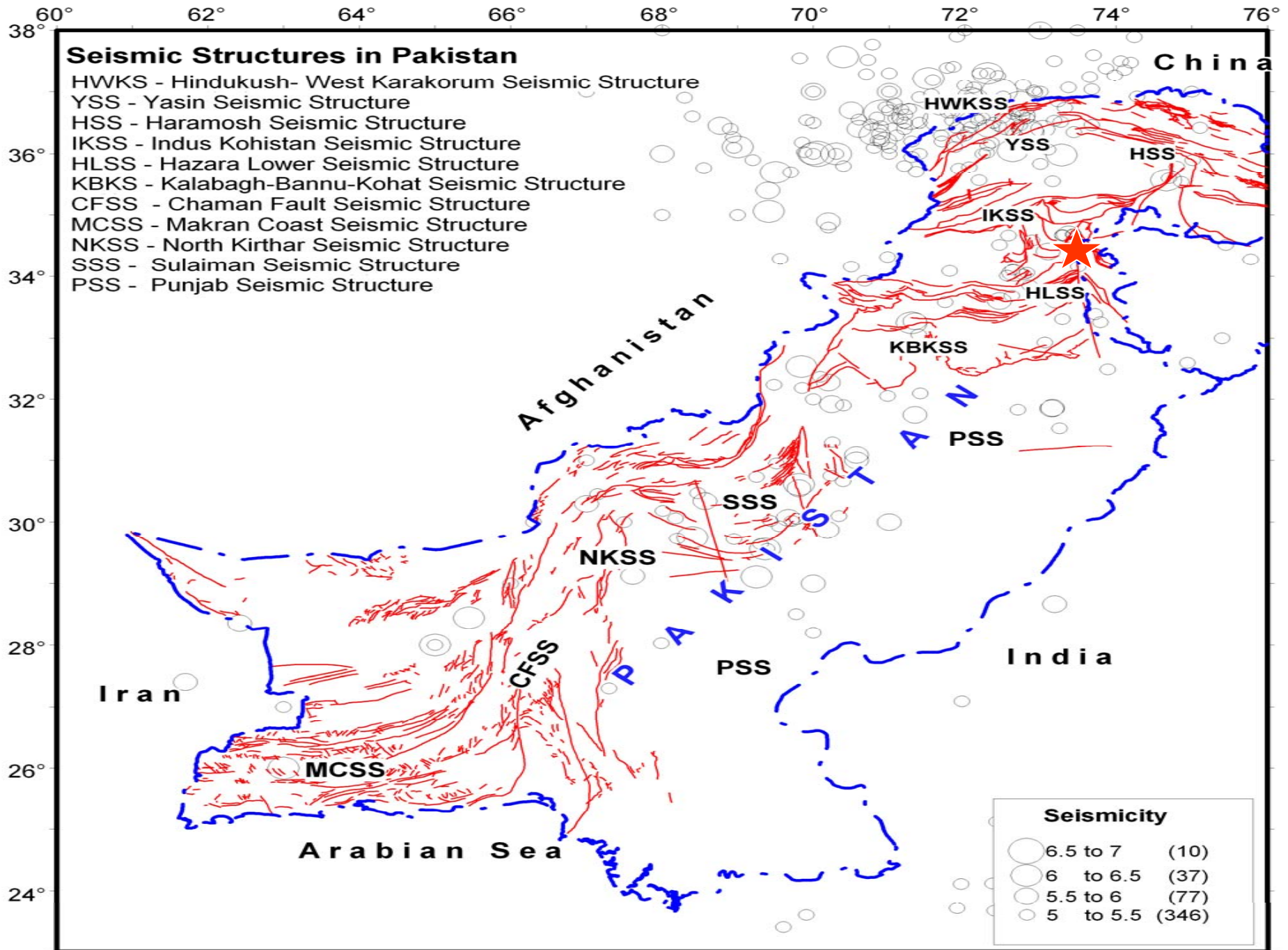


# Map showing regional tectonics of Pakistan

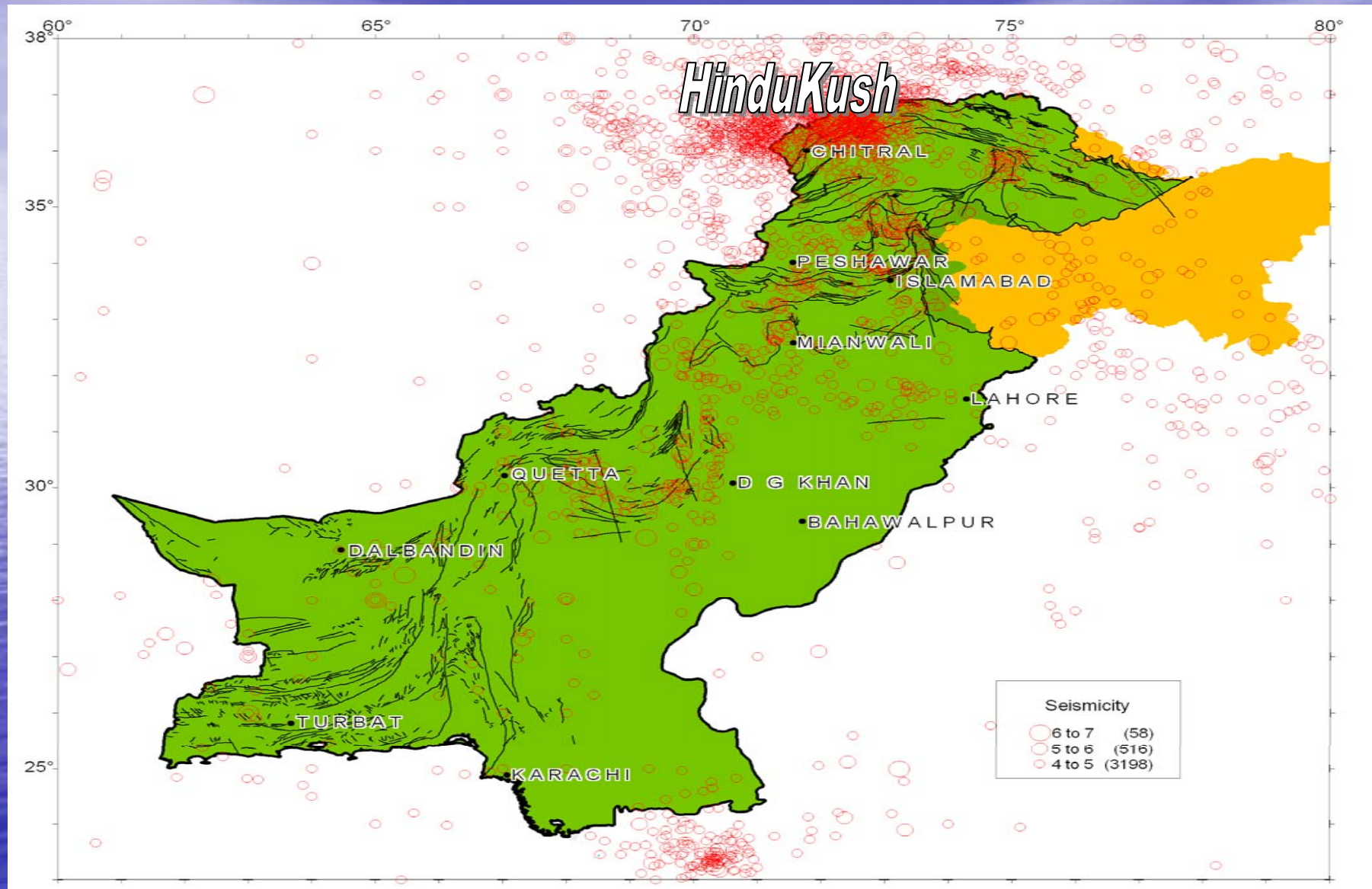




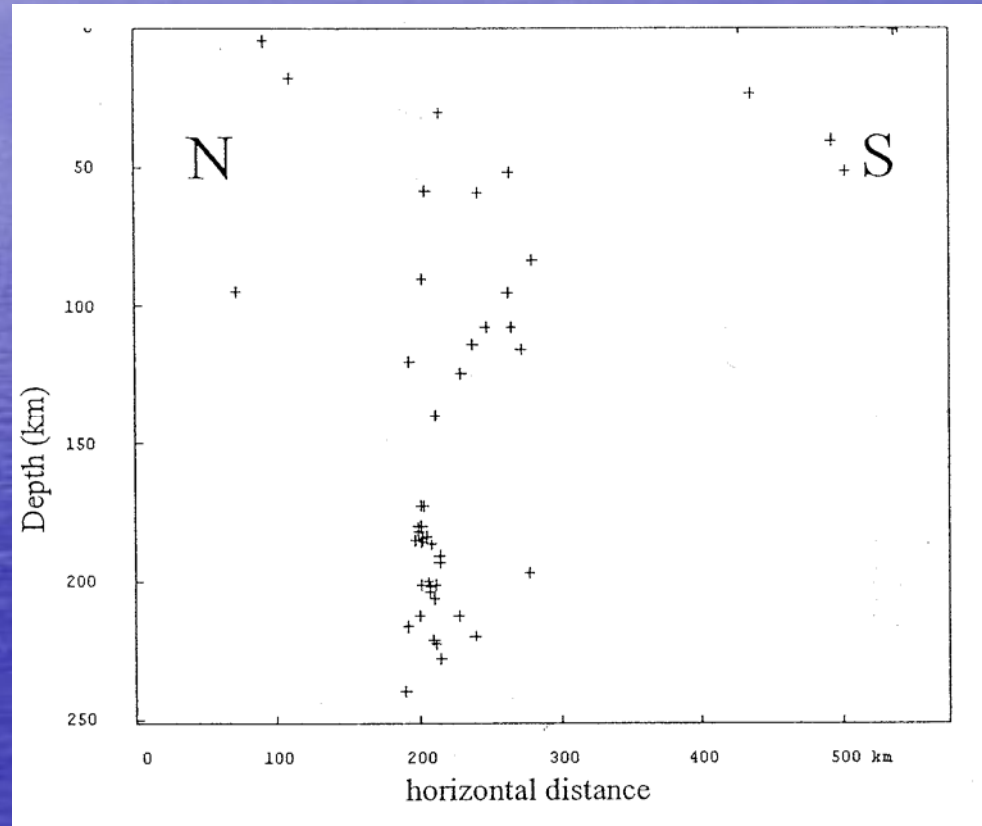




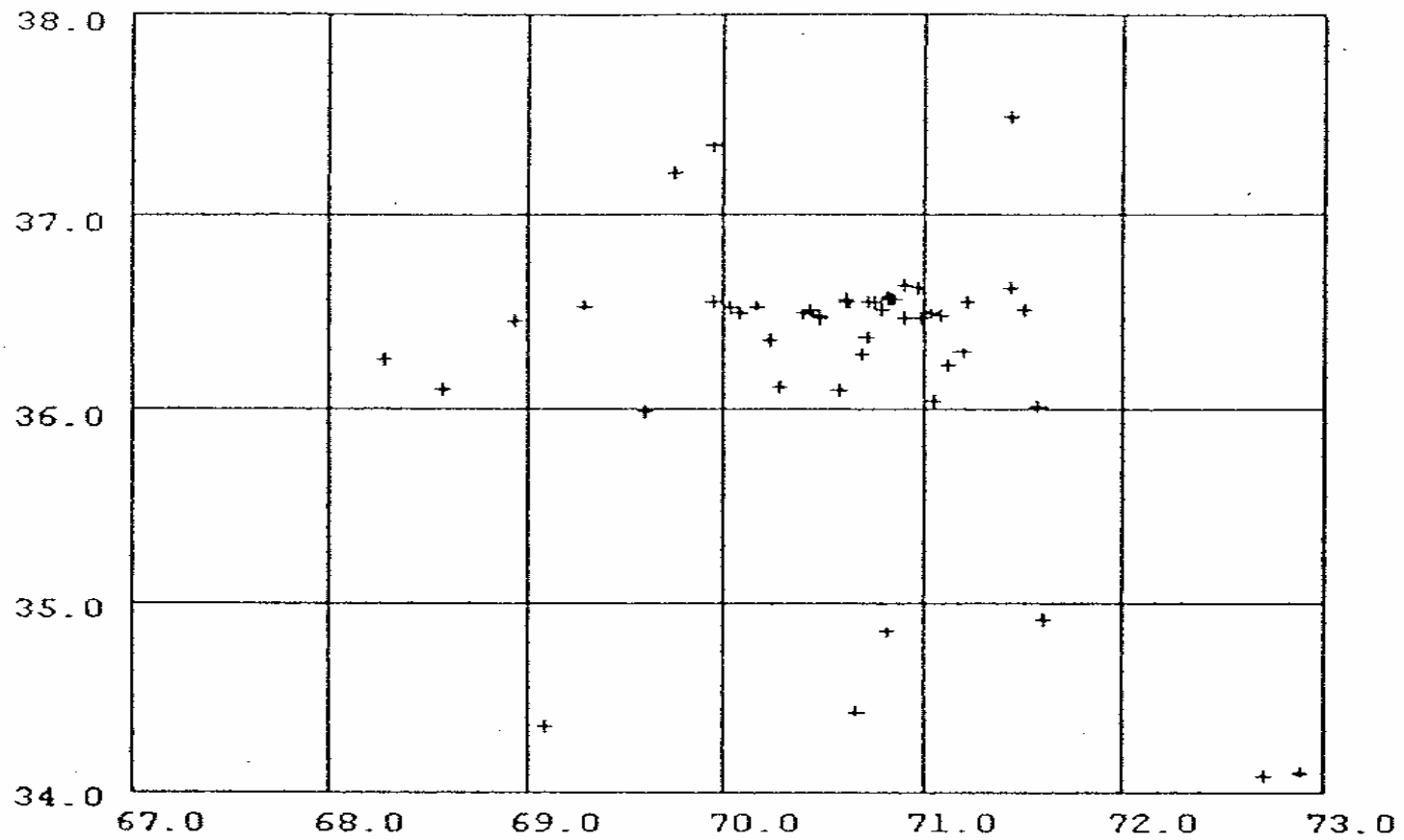
# Seismicity in Pakistan



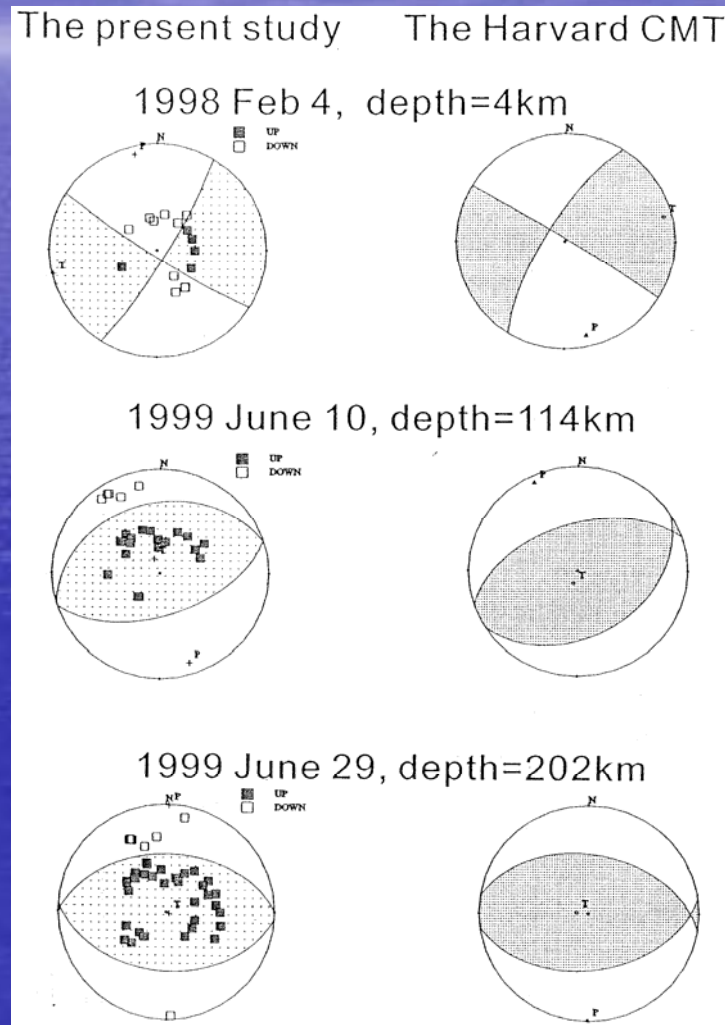
# Cross-sectional view of the seismicity for Hindukush



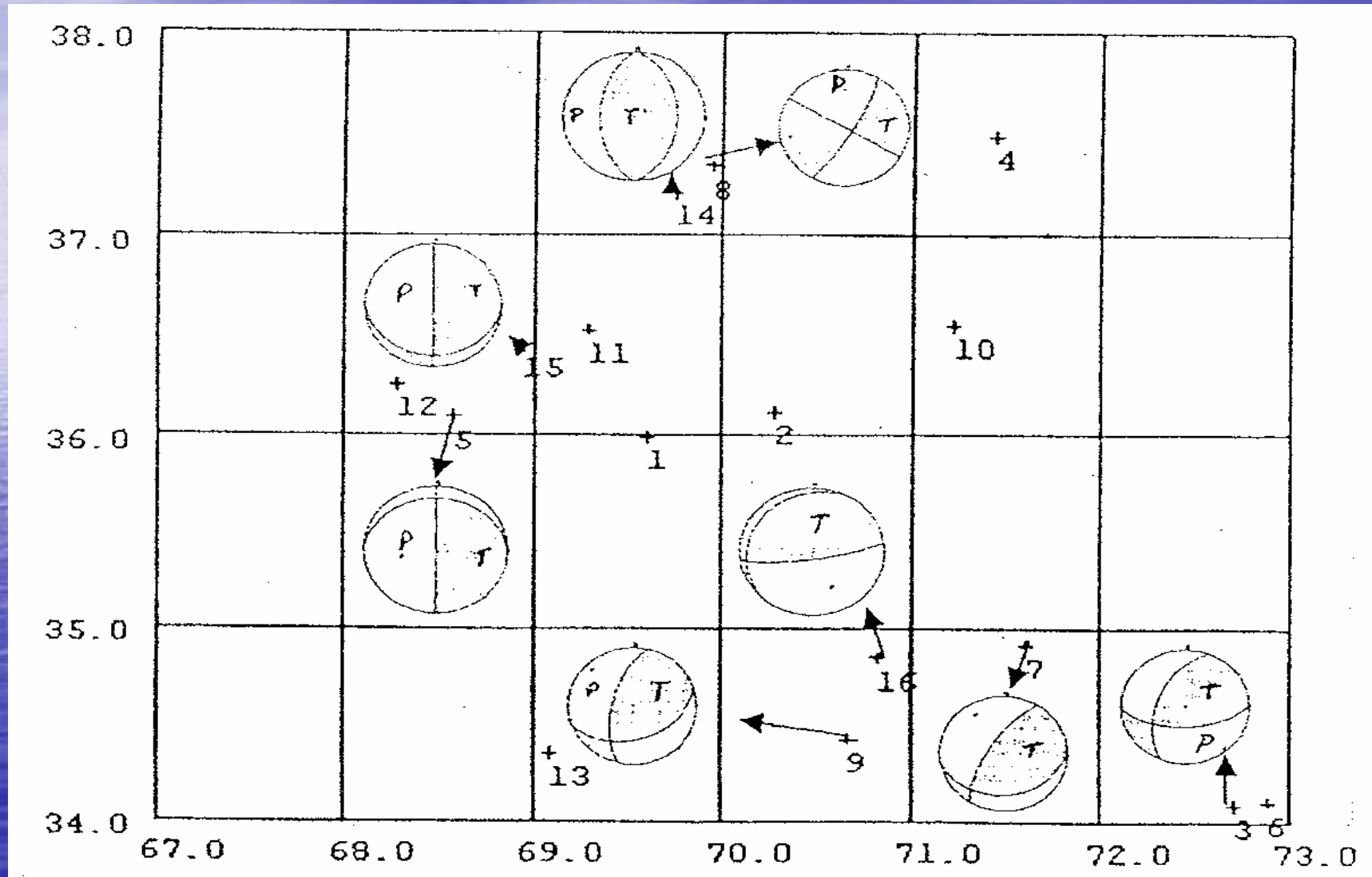
# Epicentral map view of the seismicity for Hindukush



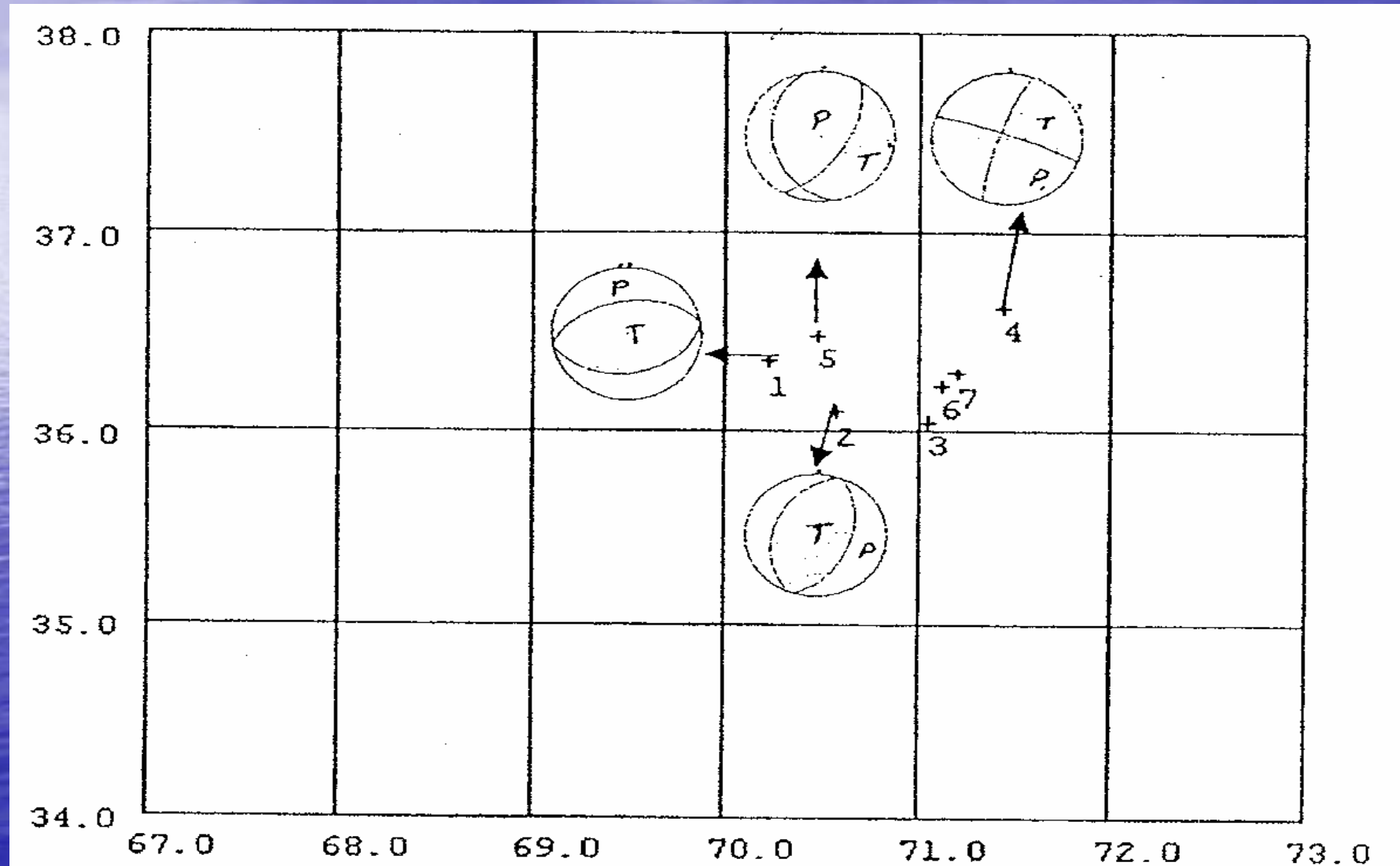
# Comparison of the fault plane solutions obtained by the present study and the Harvard CMT



# Focal Mechanism for the events of 0-100km deep



# Focal Mechanism for the events of 100-170 km deep



# Focal Mechanism for the events of 170-250 km deep

